Modeling and forecast of quality attributes for fresh fish

Case study: *Merluccius merluccius* (hake)

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Introduction

- Fish quality degradation leads to losses of around 30-50% of fish catches.
- Fish freshness has a direct impact on market price → monitoring, prediction and control tools to prevent food wastage are important
- There exists a correlation between Specific Spoilage Organism (SSOs) concentration and freshness indicators (Quality Sensory Method "QSM" or the Quality Index Method "QIM")

Objective

To develop a methodology to forecast fish freshness during storage

✓ Dynamic mathematical model describing SSO growth

✓ Expression relating QSM and QIM with SSO concentration

Model predictive capabilities

Parameter estimation from experimental data → Optimal Experimental Design (OED) to reduce uncertainty → Core predictions (Monte-Carlo method) Fish-to-fish variability → Parameter estimation from experimental data

Bacterial growth model [1]

Two spoilage bacterial groups: *Pseudomonas (Ps), Shewanella (Sh)*

$$\frac{\mathrm{d}N}{\mathrm{d}t} = \mu N\left(1 - \frac{N}{N_{max}}\right)$$

Initial conditions

$$N(t=0) = N_0$$

Growth rate*: square-root model* [2]

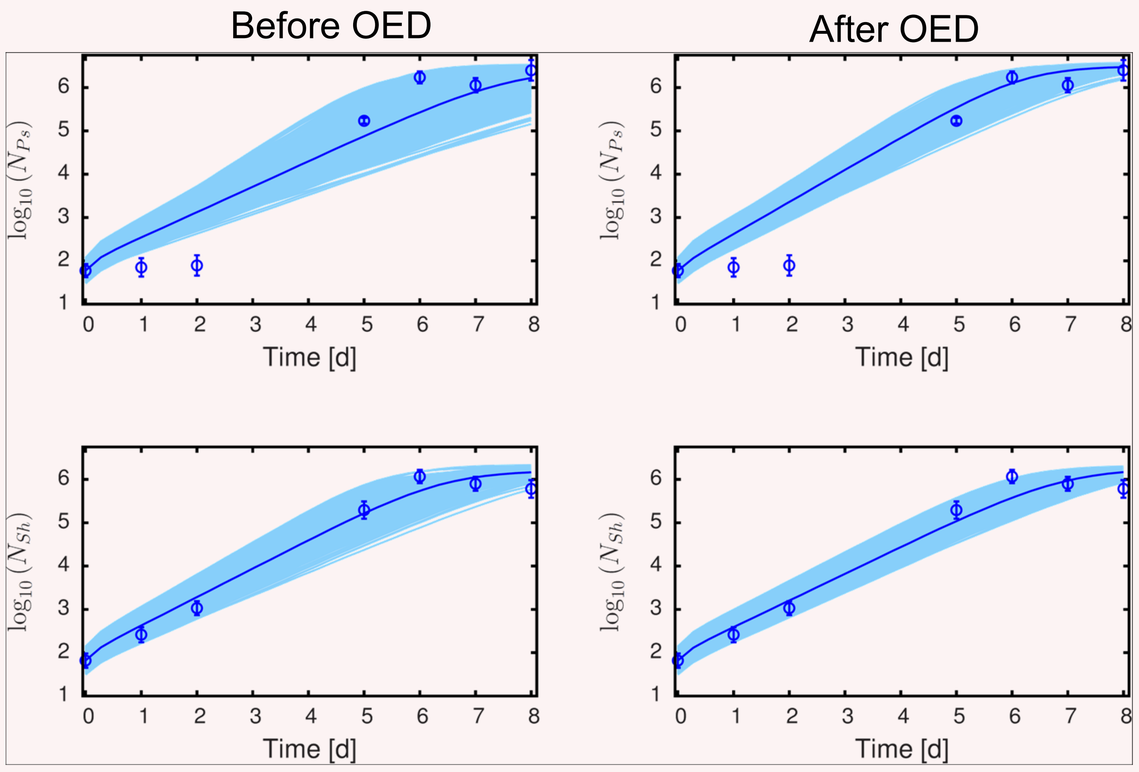
$$\sqrt{\mu} = b(T - T^*)$$

○ Parameters to be estimated

Experimental scheme

- Three experiments with constant storage temperature (1, 5 and 7 celsius) for initial parameter estimation
- One experiment (3 celsius) for validation
- Three-four specimen analyzed per sampling time
- After initial estiamtion, one optimally designed experiment (with variable temperature) was carried out

Model validation results



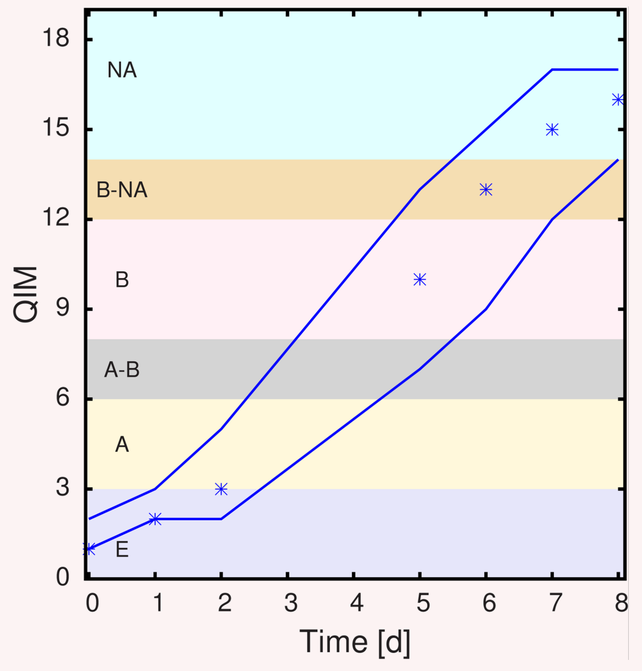
Relation QIM / Bacterial concentration

$$QIM = \mathrm{nint}(10^{lQ}) - 1$$

$$lQ = \alpha log_{10}(N_{Ps}) + \beta log_{10}(N_{Sh})$$

Time [d]	QSM (Model)	QSM (Experts)
0	E	E
1	E	E
2	A	A
5	B	B
6	B-NA	B
7	NA	NA
8	NA	NA

Quality predictions



Conclusions

- Development of a dynamic model for fish quality prediction including fish-to-fish variability
- Storage temperature is the only stress variable considered although others could be included in the methodology
- Different catching methods/effect of evisceration were analyzed [3]

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References:

[1] Baranyi and Roberts (1994). A dynamic approach to predicting bacterial growth in food. *International Int. J. Food Microbiol.*, *23*, 277–294.

[2] Ratkowsky, Olley, McMeekin and Ball. (1982). Relationship between temperature and growth rate of bacterial cultures. *J. Bacteriol.*, 149, 1-5.

[3] García, Vilas, Herrera, Bernárdez, Balsa-Canto, Alonso (2015) Quality and Shelf-life Prediction for Retail Fresh Hake (Merluccius merluccius) Accepted in *International Int. J. Food Microbiol*.